Characteristics of Emerging Road and Trail Users and Their Safety

Pedestrian and Bicycle Safety

The Pedestrian & Bicycle Safety Research Program focuses on identifying problem areas for pedestrians and bicycles, developing analysis tools that allow planners and engineers to better understand and target these problem areas, and evaluating countermeasures to reduce the number of crashes involving pedestrians and bicycles.

Introduction

Throughout the United States, the varieties and numbers of nonmotorized devices used on trail and roadway facilities have increased dramatically. People using kick scooters, in-line skates, hand cycles, recumbent bicycles, and other emerging devices compete for space with bicyclists and pedestrians. Urban trail operators report operational and safety problems associated with the increasing number of emerging users and their operational needs. User groups are petitioning State legislatures and local governments for permission to operate on roadways legally.

The standards in the American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities, which are based on the physical dimensions and operating characteristics of bicycles, may not meet the needs of these emerging users. To address this issue, the Federal Highway Administration (FHWA) sponsored a study to better understand the physical dimensions and operational characteristics of an increasingly diverse group of nonmotorized trail and roadway devices. They include the following:

- Adult tricycles
- Assistive power scooters
- Bicycle trailers
- Electric bicycles
- Hand cycles
- In-line skates
- Kick scooters
- Manual wheelchairs
- Power wheelchairs
- Recumbent bicycles
- Segway® Human Transporters
- Skateboards
- Strollers
- Tandems

Design professionals can use the results of this study to design roadway and shared-use path facilities to meet the operational and safety needs of this growing and diverse group of users.

Data Collection

Field data collection activities were conducted using bicycles and emerging devices at 21 data collection stations at three shared-use paths across the United States. The individual event locations were planned and advertised as "Rides for Science" to encourage participation by targeted user groups. Events were held at the San Lorenzo River Trail in California, the Pinellas Trail in Florida, and the Paint Branch Trail in Maryland. These "Ride for Science" events included 811 participants.

Seven data collection stations were setup at each trail. Collected data included the following:

- Physical dimensions, including length, width, height, eye height, wheelbase, wheel spacing, wheel diameter, tire/wheel width, and tire type.
- Space required for a three-point turn.
- Lateral operating space (sweep width).
- Turning radii.
- Acceleration capabilities.
- Speed.
- Stopping sight distance and time (perception/reaction and braking distances).

Physical characteristics and three-point turn widths were measured and video cameras were setup to record participants' movements at various locations along the trails. Following each data collection event, the videotapes were converted to digital format and subsequently viewed to reduce the data and determine operational characteristics for each data collection station.

Study Results

The research confirmed a great diversity in the operating characteristics of various road and trail user types. Furthermore, the research determined that it might be prudent to use an emerging user device instead of the bicycle as the design vehicle for shared-use paths or nonmotorized roadway facilities. Some examples of findings that suggest this variable design user approach follow:

Sweep Width. The AASHTO Guide for the Development of Bicycle Facilities recommends a minimum path width of 1.2 meters (m) (4 feet (ft) for bike lanes and 3 m (10 ft) for shared-use paths.

- The 85th percentile in-line skater had a 1.5 m (5 ft) sweep width, wider than the recommended width for bike lanes.
- Two in-line skaters passing in opposite directions have an approximate combined sweep width of 3 m (10 ft). Users traveling abreast in pairs or groups would require additional space. Otherwise, operations would be constrained and safety would be compromised.
- Hand cyclists require 5.4 m (17.8 ft) to perform a three-point turn.

Design Speed. AASHTO specifies 30 kilometers per hour (km/h) (20 miles per hour (mi/h)) as a minimum design speed on shared-use paths.

- Only 1 percent of bicyclists exceeded the 30-km/h (20-mi/h) speed.
- The 85th percentile speed for bicyclists was 22 km/h (14 mi/h).
- Of those users who typically operate in the street, recumbent bicyclists had the highest observed 85th percentile speed at 29 km/h (18 mi/h).
- Hand cyclists had the lowest 15th percentile speed at 8 km/h (5 mi/h).

Horizontal Alignment. AASHTO recommends a minimum horizontal curve radius of 27 m (90 ft) for cyclists traveling at 30 km/h (20 mi/h) around a curve with a 2 percent superelevation.

- Most users do not appear to reduce their speeds for radii greater than 16 m (50 ft).
- The exception is recumbent bicyclists, who may have been constrained by even the 27-m (90-ft) radius.

Stopping Sight Distance. The required stopping sight distance of users depends on their travel speed, eye height, reaction times, and deceleration capabilities. AASHTO recommends a stopping sight distance of 38.7 m (127 ft) for a bicyclist traveling at the recommended design speed of 30 km/h (20 mi/h) on wet pavement.

- The 85th percentile bicyclist requires a stopping sight distance of only 12.4 m (41 ft) on dry pavement and 19.4 m (64 ft) on wet pavement.
- A recumbent cyclist in the 85th percentile requires a stopping sight distance of 32.7 m (107 ft) on wet pavement.

Vertical Alignment/ Crest Vertical Curves. The minimum length of a crest vertical curve depends on the user's stopping sight distance and eye height and the algebraic change in grade. Given a 10 percent change in grade, AASHTO's minimum length of a crest vertical curve for a bicyclist with its presumed 38.7-m (127-ft) stopping sight distance is 49.8 m (163 ft).

- This FHWA study found that observed stopping distances for bicyclists yield a required length of a crest vertical curve of only 20.4 m (67 ft).
- Recumbent bicyclists are the critical design user, with a required length of a crest vertical curve of 46.7 m (153 ft).

Refuge Islands. Refuge islands are provided between opposing motor vehicle traffic flows to allow pathway users to cross only one direction of traffic flow at a time. The AASHTO Guide for the Development of Bicycle Facilities states that a refuge island width of "2.0 m(6 ft) is poor, 2.5 m (8 ft) is satisfactory, and 3.0 m (10 ft) is good."

- Recumbent bicycles, bicycles with trailers, and hand cycles all have 85th percentile lengths greater than 1.8 m (6 ft).
- Bicycles with trailers exceed 2.4 m (8 ft) in length.

Signal Clearance Intervals. Yellow plus all-red intervals for motor vehicles typically are 5 seconds or less.

- Five-second clearance intervals provide insufficient time for most users (85th percentile users) to clear a five-lane, 18.3-m (60-ft) wide intersection.
- The kick scooter appears to be the critical user type.

Pedestrian Clearance Intervals. Pedestrian clearance intervals are intended to allow pedestrians who begin crossing a signalized intersection any time before the beginning of the flashing "DON'T WALK" phase to completely cross the street before crossing traffic enters the intersection. Typically, pedestrian signals are timed for walking speeds of 1.2 meters per second (m/s) (4 feet per second (ft/s)). The manual wheelchair users evaluated were able to cross intersections within the time provided for an assumed 1.2-m/s (4-ft/s) walking speed.

Segway Human Transporter User Characteristics. Based on the performance of the five Segways evaluated in the study, a Segway user would not be the critical user for any of the design criteria evaluated.

- Many characteristics of Segway users are comparable to those of other emerging trail users.
- Compared to most other users, Segway users had higher eye heights, shorter lengths, shorter braking distances, and faster deceleration rates, and required the least space to make a three-point turn.

Table 1. Design Criteria and Potential Design Users

Design Feature	AASHTO Design Value (for Bicyclists)	Potential Design Device/User	Performance Value (85th Percentile)
Sweep width	3 m	In-line skaters	1.5 m
Horizontal alignment	27 m	Recumbent bicyclists	26.8 m
Stopping sight distance (wet pavement)	38.7 m	Recumbent bicyclists	32.7 m
Vertical alignment/ crest (5% grades)	49.8 m	Recumbent bicyclists	46.7 m
Refuge islands	2.5 m	Bicycles with trailers	3.0 m
Signal clearance intervals	7.5 s for a distance of 24.4 m	Kick scooters	10.6 s for a distance of 24.4 m
Minimum green times	12.8 s for a distance of 24.4 m	Hand cyclists	17.9 s for a distance of 24.4 m
Pedestrian clearance intervals	20.0 s for a distance of 24.4 m	Manual wheelchairs	15.4 s for a distance of 24.4 m

1 ft = 0.305 m

Table 1 represents potential facility design criteria and design users based on the FHWA study.

Summary

While additional research is needed to determine which devices should be used to set specific design criteria, the findings suggest that design guidelines might need to be revised to incorporate the needs of emerging road and trail users. The results of this study can be used to help design professionals adequately design roadway and shared-use path facilities to meet the operational and safety needs of this growing and diverse group of nonmotorized users.

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